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Analyses of the effects of Avocado oil on mild steel corrosion in 1 M of sulphuric acidic solution

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Abstract-

This study investigates the effects of Avocado oil on mild steel corrosion in 1 M H₂SO₄ solution using gravimetric method and its requisite analyses. Concentrations of the oil for the acidic environment were varied for their anticorrosion effectiveness study on the metal. Results obtained show the organic inhibitor compound maintained excellent inhibition efficiencies at 5% concentration of the avocado oil, while the lower concentrations of the oil exhibited increasing trends of effectiveness, on the mild steel corrosion. That this result is suggestive of being due to the adsorption reaction of the avocado oil on the surface of the mild steel samples was detailed via the Langmuir adsorption isotherm modelling analyses presented in study.

Key words: Mild steel; avocado oil; corrosion rate; corrosion inhibitor and inhibition efficiency; gravimetric analysis; Langmuir adsorption isotherm

1. Introduction

Mild steel has a wide range of use in the engineering world today making it very valuable but the effect of metallic corrosion on mild steel cannot be overlooked, this is a big problem to engineering, the damages corrosion causes and the cost of maintenance of this metal is high [1-3]. Mild steel have a weak resistance to corrosion which has a negative impact on its versatile application and good mechanical properties [4-6]. Chemical compound which are known as corrosion inhibitors has been effective in the protection of this metals from corrosion [7-9]. This inhibitors reduces the electrochemical reaction and properties mechanism of the corrosive environment reacting to the metallic surfaces. [10, 11], experiment which have being performed using organic inhibitor shows high effectiveness and resistance to corrosion [12-13]. Avocado oil which is an organic inhibitor is used in this experiment to control the rate of corrosion on mild steel immersed in 1 M of H₂SO₄, an acidic environment in which mild steel is always prone to corrosion due to the strong negative effect of acid on this metallic material [15]. This article focuses on the electrochemical effects of corrosion inhibition of avocado oil on mild steel in 1 M of H₂SO₄.

2. Experimental

2.1 Materials and setup

Mild steel sample were commercially obtained and were machined into samples of corrosion test coupons. The mild steel samples were prepared and cleaned with abrasive papers, distilled water and acetone. The acidic solution of H₂SO₄ was prepared with distilled water to 1 M of 200ml. The avocado organic inhibitor was added in concentrations of 1% to 5% concentration, at 1% increments, into the acidic solution of 1 M H₂SO₄. Gravimetric experiment, via weight loss measurements, was initiated by cutting the metals into 6 samples of equal sizes of 1 cm by 1 cm by 0.3cm, while the acid solution that had been made up to 1 M of H₂SO₄ using distilled water the requisite amount of inhibitor added. The control acidic sample had no inhibitor added into the solution. The metallic samples were placed into the acidic environment with different inhibitor concentration for a period of 504 hours and at



every 24 hours interval the weight loss value is measured. From the measured weight loss value (W), the mild steel surface area (A), density of mild steel (D), and the immersion time (T), the corrosion rate (CR) was computed by the formula [16-17]:

$$CR = \frac{87.6W}{DAT} \quad \backslash * \text{MERGEFORMAT (1)}$$

From this equation, the corrosion inhibition efficiency, $IE(\%)$, calculation proceeds from the corrosion through the formula [17]:

$$IE(\%) = \left[\frac{CR_{control} - CR_{with\ Avocado\ oil}}{CR_{control}} \right] \times 100 \quad \backslash * \text{MERGEFORMAT (2)}$$

3. Result and discussion

Analyzed results obtained from the research experiment are as presented. The gravimetric weight loss, estimated corrosion rate, corrosion inhibition efficiency and surface coverage values were determined from the experimental results. Figure 1 present the plots of result obtained from the gravimetric weight loss experiment, while Figure 2 shows plots of estimated corrosion rate from the gravimetric weight loss of the mild steel in the 1 M H_2SO_4 , for the 504 hours of experimental period. Both figures show that 0% sample remained uninhibited in corrosion by exhibiting the highest losses in weight of up to 0.9532 g and in corrosion rate of up to 6.5753 mm/y in the severe environment setup for the study. This is due to the activity of the SO_4^{2-} ion, which promotes the redox reaction between the metal and the acidic solution. Results from the system with 1%, 2%, 3% and 4% inhibitor concentration inhibited the samples by retarding the dissolution of the metal samples, which are suggestive of passivation of the metal most probably with a form of adsorption protection on the metallic surface. In addition, the sample with 5%, which represents the highest inhibition concentration percentage for the study, is indicating an improved form of adsorption reaction that is retarding to the activity of the SO_4^{2-} ion and passivating the metallic surface. This resulted in the weight loss reduction to 0.0393 and the corrosion rate reduction to as low as 0.2711 mm/y.

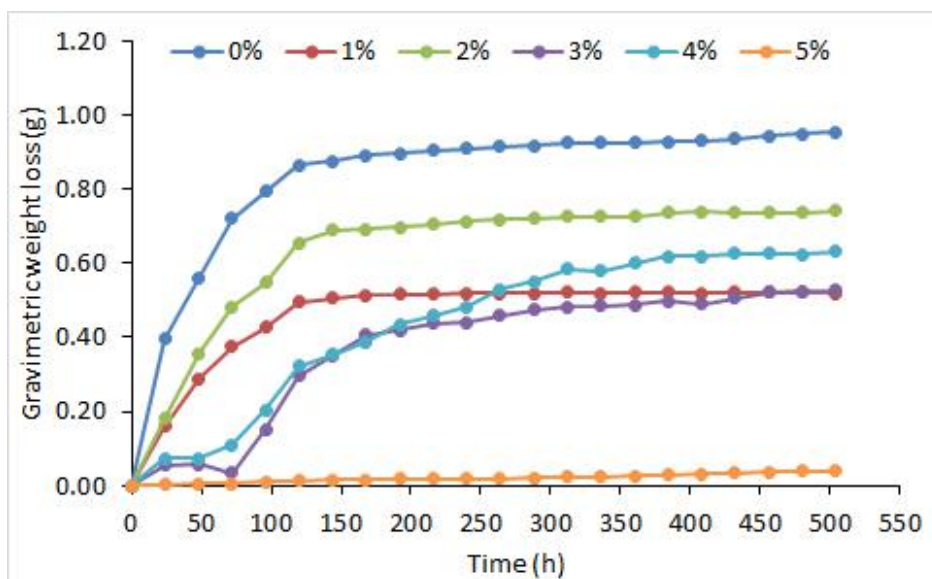


Figure 1: Gravimetric weight loss of mild steel in 1 M H_2SO_4 having avocado oil concentrations

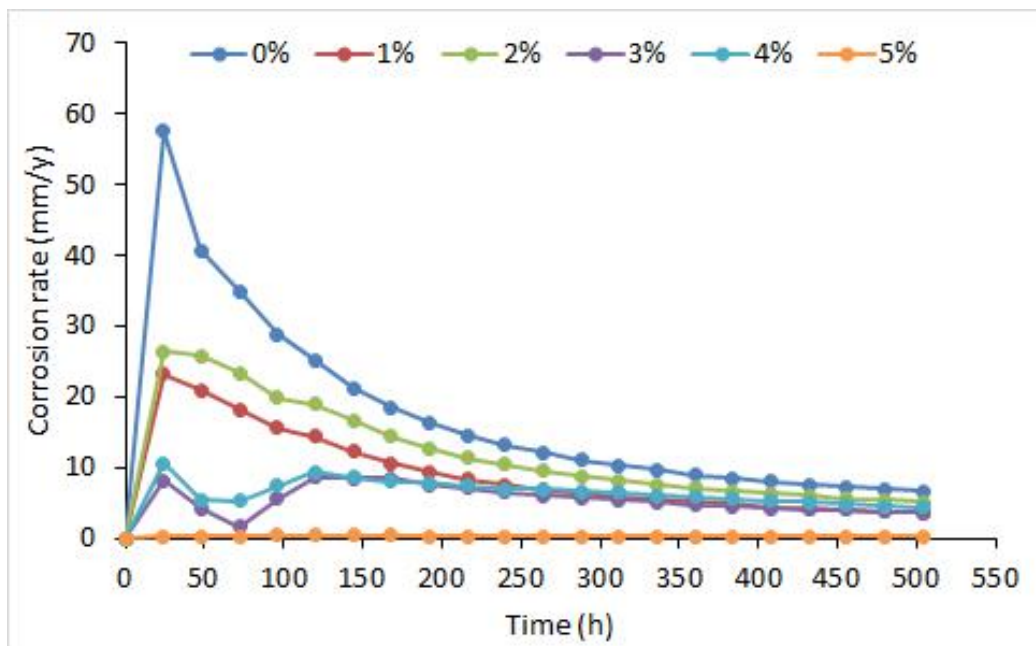


Figure 2: Corrosion rate graph of mild steel in 1 M H_2SO_4 having avocado oil concentrations

Furthermore, results of corrosion rate in Figure 2 that were used for estimating the corrosion inhibition efficiency gave the plots presented in Figure 3. This plots showed that the corrosion rate reduction that was observed with the sample having the 5% concentration resulted in corrosion inhibition efficiency that was greater than 99% from the first 24 hours and which was maintained throughout the 504 hours of experimental period.

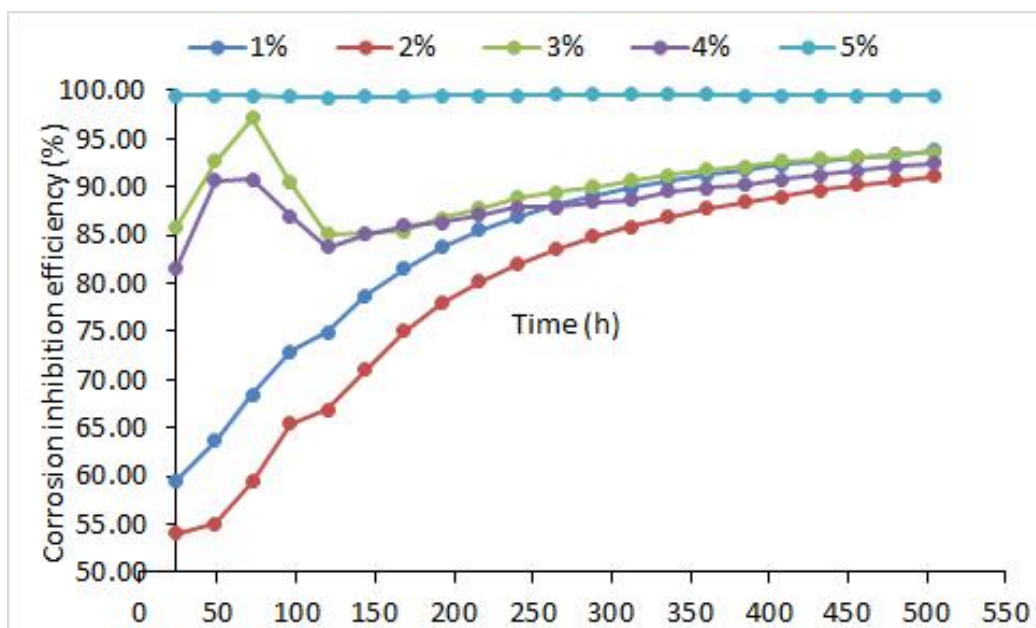


Figure 3: Inhibition efficiency graph of Mild Steel in H_2SO_4 using Avocado oil as organic inhibitor

In comparisons, other concentrations of avocado oil that were used in the study showed, in the overall, an increasing trends of corrosion inhibition through the 504 hours of experimental period. The slight exception to this was the decreasing trends of corrosion inhibition efficiency from the 3% and 4% avocado oil test-system between the 48 and 96 hours, but which showed recovery in inhibition efficiency towards increasing trends after the 96 hours until the 504 hours of experimentation. The implication of these could be due to a system of improving adsorption mechanisms on the mild steel surface as the experimental time progresses. However, consistent corrosion-protection of the mild steel material was maintained throughout the experimental period by the system having 5% avocado oil, which is indicative of the consideration that the high concentration of avocado oil effectively mitigated mild steel corrosion in the acidic sulphate environment. These modes of results spark interest on the study of the adsorption characteristic of the avocado oil on mild steel metallic surface.

The plots from the adsorption isotherm study are as presented in Figure 4. For the fitting, the Langmuir adsorption isotherm modelling approach was employed [17-18]. These plots in the figure followed a quasi-linear trends for most of the experimental measurement times that were plotted. From these isotherm models, the estimated parameters that were analyzed include the adsorption-desorption coefficient, K_{ads} , the model fitting efficiency, R^2 , the Gibbs free energy of adsorption, ΔG_{ads} , and the separation factor, R_L [17-21].

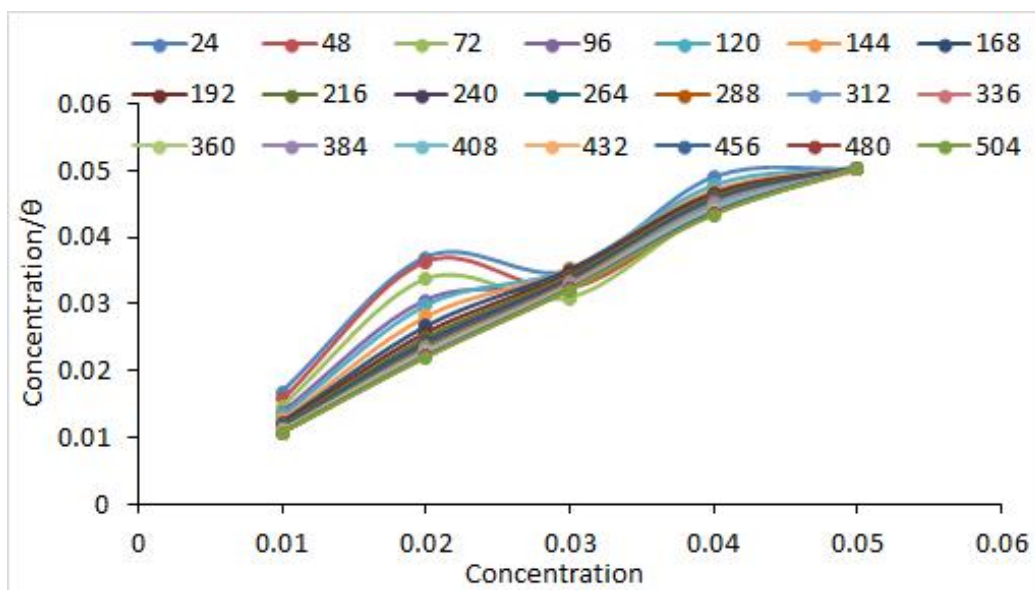


Figure 4: Plots of Langmuir adsorption isotherm model of avocado oil corrosion-protection mechanism on mild steel in 1 M H_2SO_4

The plots of the K_{ads} and of the R^2 are presented in Figure 5 while the plots of the Gibbs free energy, ΔG_{ads} (kJ/mol), and of the separation factor, R_L , obtained from the modelling analyses are presented in Figure 6. The plotted values in Figure 5 showed that increasing positive values of the adsorption coefficient, K_{ads} , as well as an excellent fitting models by the Langmuir adsorption isotherm to the mild steel corrosion data, via the R^2 that increased from 85.30% to the predominance of >94% till it attains 99.42% by the 504th hour.

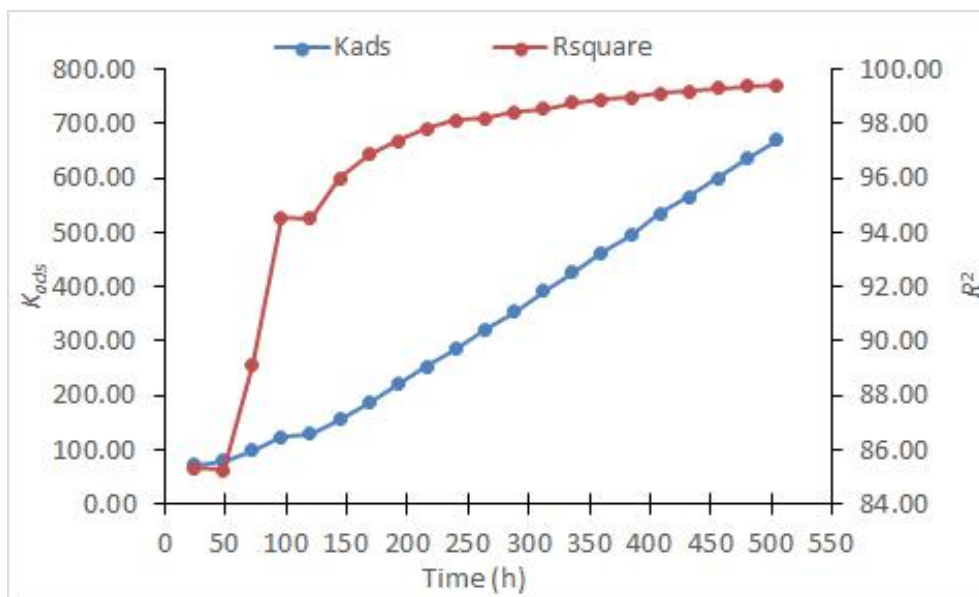


Figure 5: Plots of K_{ads} and R^2 parameter values from the Langmuir adsorption isotherm modelling of avocado oil corrosion-protection on mild steel in 1 M H_2SO_4

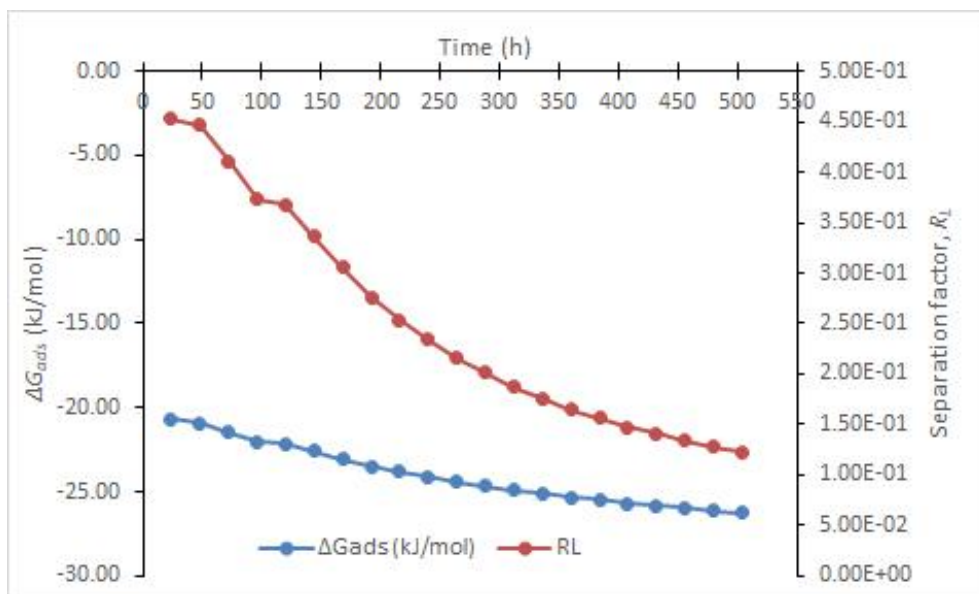


Figure 6: Plots of Gibbs free energy, ΔG_{ads} , and separation factor, R_L , parameter values from the Langmuir adsorption isotherm modelling of avocado oil corrosion-protection on mild steel in 1 M H_2SO_4

Also, the Gibbs free energy plots in Figure 6 showed that negative values, ranging from -20.68 kJ/mol to the more negative value of -26.25 kJ/mol were estimated for this parameter, which indicates spontaneity of the adsorption process by the avocado oil on the mild steel. These results showed that the prevalent mechanism of avocado oil adsorption on mild steel is physisorption, due to the ΔG_{ads} that were valued at more negative values -20 kJ/mol, but which could be said to exhibit some degrees of chemisorption due to the observed decreasing trend towards -40 kJ/mol. Also, the values of the separation factor, R_L , that was in the range 0

$< R_L < 1$, throughout the experimental period as shown in Figure 6, indicate favourable adsorption [18-20] by avocado oil on the mild steel metal.

4. Conclusion

Avocado organic compound effectively enhanced the corrosion resistance of mild steel samples in H_2SO_4 solution. The organic compound passivates the mild steel samples by lowering the corrosion rate from the active site of the acidic solution. From the analyzed adsorption models, it could be deduced that the effectiveness of avocado organic inhibitor most probably proceeds from the high functional group, heteroatomic nature and other molecular species that form strong bonding formation on the mild steel surface. These must have been responsible for the observed retardation of the high redox reaction of the acidic solution on the mild steel metal.

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